DOCUMENT RESUME

ED 209 261 TM 810 742

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TITLE Chicago Mastery Learning Reading: Mastery Learning Instruction and Assessment in Inner City Schools.
PUB DATE May 81
NOTE 28p.; Paper presented at the Annual Meeting of the International Reading Association (New Orleans, LA, May, 1981).

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Achievement Tests; Criterion Referenced Tests; *Data Analysis; Elementary Education; *Mastery Learning; *Models; *Program Evaluation; *Reading Programs; *Scores
IDENTIFIERS *Chicago Public Schools IL

ABSTRACT

The Chicago Public Schools have been developing and implementing a citywide instructional program of continuous progress/mastery learning in reading. It includes the delineation of a K-8 continuum of instructional objectives; a criterion-referenced testing program which serves as the basis for instruction, promotion, and administrative monitoring; and a mastery learning instructional system: the Chicago Mastery Learning Reading materials for teachers. The Chicago mastery learning model differs from other mastery learning models in three major regards: (1) it welds mastery learning theory with theories of cognition and learning and with concepts relating to instruction; (2) it emphasizes group instruction; and (3) its delivery system emphasizes materials development rather than staff development. In evaluating the effects of this innovation, the theory of mastery learning was used to infer specific changes and patterns of changes which ought to occur in achievement test scores, thus enriching the interpretation of that data. (Author/BW)

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CHICAGO MASTERY LEARNING READING:

MASTERY LEARNING INSTRUCTION AND ASSESSMENT

IN INNER CITY SCHOOLS

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Ruth B. Love

General Superintendent of Schools

Board of Education

City of Chicago

Paper presented at the annual meeting of the International Reading Association, New Orleans, May 1981.

CHICAGO MASTERY LEARNING READING:

MASTERY LEARNING INSTRUCTION AND ASSESSMENT

IN INNER CITY SCHOOLS

In response to the widespread problem of low reading achievement in urban schools, the Chicago Public Schools have for a number of years been developing and implementing a citywide instructional program of continuous progress/mastery learning in reading. The "Chicago Plan" (Hannon & Katims, 1979) for mastery learning started with the delineation of a K-8 continuum of instructional objectives and the shift from graded schools to schools organized by reading levels. Since that time, Chicago has also implemented citywide a criterion-referenced testing program which serves as the basis for instruction, promotion, and administrative monitoring. The latest component of the program is a mastery learning instructional system: The Chicago Mastery Learning Reading (CMLR) materials for teachers. These materials are comprehensive, providing teachers with teaching activities, corresponding pupil learning activities, formative tests for instructional feedback, and corrective instructional activities for those who fail to master objectives. In the fall of 1980, CMLR materials were delivered to all of Chicago's elementary schools. Although we have no way of knowing exactly how many teachers use the materials in Chicago, the developers have inserviced over 5,000 teachers and administrators since the inception of the program. Moreover, we know that the materials are mandated in several districts and in numerous schools either for use during the regular year or during the summer (see Note 1). CMLR materials are also being used in other cities in the U.S. (e.g., New York City, Philadelphia, and Dallas) and Canada.

Previous articles (Jones & Katims, 1980; Jones, Monsaas, & Katims, 1979; Katims, Smith, Steele, & Wick, 1978) have reported on development and field testing, experimental research, and limited implementations of the materials

during 1976-79. The purposes of this paper are twofold: 1) to describe the instructional materials and the features that distinguish the Chicago model of mastery learning instruction from other models of mastery learning, and 2) to describe innovative ways to examine the effects of mastery learning instruction, given that school data is often limited to norm-referenced tests and that it is often "messy" data which is lacking in controls. Moreover, it is important to note that this paper is written from the point of view of the practitioner in that it addresses the question: How can the available data be used as the basis for improving instruction and student achievement in classrooms and schools?

Chicago's Mastery Learning Program in Reading

The philosophy and techniques of mastery learning are particularly suited to the instructional and administrative needs of a large school system. The belief that all children can learn is consistent with the obligations of universal education, and the specification of the elements of quality instruction provides a framework for the systemwide management of instruction. The Chicago Public Schools have been committed to this philosopny and these techniques for some time and have been building the continuous progress/mastery learning (CP/ML) program for over a decade. Each step of development has more completely specified and standardized aspects of the system. And with the imminent completion and implementation of the instructional system, we may have in place a technology for districtwide improvement.

The first step in the development of a mastery learning program is the specification of a sequence of instructional objectives. Accordingly, Chicago developed the Curriculum Guides in Elementary Reading which specify a K-8 continuum of over 1400 instructional objectives. These guides state the objectives and give clear behavioral formats as teaching/testing models. Of

these 1400 objectives, a selected set of 273 "key" objectives was identified on an individual pupil mastery record card where teachers could record each student's mastery of the specific key objectives. Furthermore, the traditional graded school was abandoned and schools were organized around the 13 reading levels of the continuum. At this stage, all pupils were identified, grouped, and taught in terms of the standard set of instructional objectives so that placement and progress could be maintained in common terms citywide.

However, there were still problems. Some teachers found that students in their classrooms had not really mastered skills that were marked on their cards. So a central set of criterion-referenced tests (CRTs) was developed for standardized assessments of mastery of the key objectives. Even more vexing was the citywide dilemma that students simply were not making appropriate progress through the matrix of objectives and tests. Principals generally did not use the tests and record cards to monitor and improve instruction or to increase the expectations for progress. So a system of administratively imposed expectations or goals and accompanying monitoring forms and procedures were instituted. Yet even with these tools for school improvement, progress has been slow and marked by frustration. There were simply too many objectives and tests to be mastered in order to meet the goals, using traditional reading materials.

The CMLR materials are designed to address this fundamental problem of schooling. For each of the thirteen levels of the reading curriculum, teachers are provided with two parallel sets of mastery learning instructional units: comprehension units which teach the comprehension objectives and skills units which teach word attack and study skills objectives. Each unit contains all the materials necessary to help the majority of pupils in the classroom master the objectives. Each unit includes detailed and structured teaching lessons for presenting the instructional narrative and learning clues; corresponding learning activities that allow the pupils to practice the skills in the formats in which

they will be evaluated; formative tests to identify successful pupils and those who require more work; and structured, self-contained, corrective instructional exercises that provide alternative learning cues and additional practice opportunities. The instructional units address the objectives assessed by the CRTs, and with them teachers can help whole classrooms of students master objectives at an acceptable rate.

The mastery learning model promotes success by combining the teaching efficiency of group instruction with the precision of individualized remediation for those who require alternate learning opportunities. But the CMLR units ensure high levels of achievement because they were field tested and revised until they did so, using a concept of criterion-referenced field testing. That is, through our model of development and field testing, the developers assume the responsibility for mastery learning results rather than impose the burden on teachers or pupils. We have found, for example, that mastery learning instruction in elementary reading is not practical if 50-60% of the pupils do not achieve mastery by the time of the formative test. Therefore, if a sequence of instructional activities does not produce these results in our field test classrooms, we redesign the sequence until it does. Similarly, if the remedial instruction does not lead another 20-30% to mastery, we revise it accordingly.

In order to attain these high levels of achievement, we have built in a number of other features into the materials, most notably a distinctive instructional sequence as well as specific learning strategies instructions which provide the students with information about the structural characteristics of the texts that they read. 1) Instructional Sequence: To accommodate deficiencies in prior learning as well as the learning needs of slower learners, each unit is carefully designed and sequenced. Initial activities require almost no prerequisites. They begin with little or no reading; a great deal of teacher direction; simple, concrete content; and structured responses. Each subsequent

activity is progressively more difficult and abstract and has fewer instructional supports. The number of activities per unit and the degree of difference between them are determined during field testing. 2) Learning Strategies and Structure of Text: In addition to teaching the reading objectives, the units incorporate the teaching of specific learning strategies: a variety of mental operations for organizing memory, solving problems, and facilitating comprehension. For younger pupils, these strategies and procedures are modeled in the instructional presentation. In the materials for upper elementary pupils (grades 5-8), the strategies are explicity taught through the use of adjunct questions and paradigms and the provision of information about the structure of the texts. Essentially, these paradigms provide "thinking aloud", step-by-step instructions which guide the student to comprehend what is read by analyzing the text structure and by making inferences from inexplicit texts (i.e., texts which require inferences). Thus, the instruction focuses explicitly on the higher cognitive skills, promoting the development of what Bloom calls "learning to learn." Pupils are taught how to think about the problem and thus gain confidence to confront new learning situations.

The Chicago mastery learning model differs considerably from other mastery learning models in three major respects. First, the Chicago model welds mastery learning theory with theories of cognition and learning and with concepts relating to instruction: learning strategies theory (see Levin & Allen, 1976; O'Neil & Spielberger, 1979; Rohwer, 1971), theories of knowledge acquisition (e.g., Anderson, Spiro, Montague, 1977), structure of text research (e.g., Meyer, Brandt, & Bluth, 1978), metacognitive research (e.g., Brown, 1980), adjunct question research (e.g., Andre, 1979), and research on the sequencing of skills instruction (e.g., Rosenshine, 1980; Stoll, 1980). (Descriptions of the rationale for this welding of theories may be found in Jones, 1980; Jones, Katims, & Amiran, 1980.)

Second, the Chicago model emphasizes group instruction. While this is not a unique characteristic (e.g., Abrams, 1980), most mastery learning implementations emphasize some variation of individualized instruction. CMLR developers rejected individualized methods of instruction primarily because individualized models may create or maintain individual differences (see Arlin, 1980; Resnick, 1980, Note 2) if monitoring or pacing mechanisms are not built into the model. However, even if such mechanisms are available, our early pilot observations (before developing CMLR) indicated that ability grouping within the same classroom seemed to be very difficult to manage for many teachers, expecially intermediate and upper elementary teachers who are not trained in ability-group management as primary teachers are. Moreover, the teachers had constant problems in preparing, storing, grading, and organizing the diversity of appropriate instructional materials each day. Finally, it seemed that ability grouping tended to limit the available instructional time and opportunities for individual participation for each group, did not promote increased time on task in the groups doing seatwork while the teacher was instructing another group, and, because of all these problems, was frequently overtly disliked by teachers. Our observations about engaged learning time are consistent with research on time on task (e.g., Rosenshine, 1979; Wiley, 1978) and classroom research (e.g., Rosenshine, 1979).

Third, the Chicago mastery learning model contrasts sharply with all other mastery learning models in its delivery system, i.e., materials development rather than staff development. Research on staff development (e.g., Joyce & Showers, 1979; Berman & Pauley, 1979) suggests that it is frequently ineffective in improving instruction and/or student achievement because student achievement goals are frequently not specified in staff development projects and because there is frequently little or no follow-up to establish that the prescribed instruction was implemented in the classroom. While there are clearly some highly

effective mastery learning staff development models which do specify achievement goals and provide follow-up instruction and monitoring in the classroom (Bailey & Guest, 1980; Barber, 1979; Kopple & Conner, 1980; Reid, 1978), these models are most often implemented in teaching/learning environments that are quite different from those in Chicago. In general, these models are implemented in very small or medium-sized districts or on a limited basis in large urban districts. Moreover, these successful models involve extended periods of training and after-school preparations on the part of the teacher or principal who are usually volunteers in such projects.

In Chicago, the teaching/learning conditions precluded utilizing a staff development model. Chicago has 23,000 teachers teaching in 500 schools. While the existing staff development program does provide opportunities for intensive training of resource teachers, it was not devised to provide extensive training in mastery learning instructional strategies. Moreover, after-school time for preparation of materials and record keeping were already heated union-administration disputes. But even if there had been both administrative and union support for a mastery learning staff development model, there was the problem of teacher changes due to absenteeism, transfer, drop out, sick leaves, desegregation rulings, staff reductions, and regular building reorganization. Additionally, there is a sizeable population of fulltime substitute teachers who are not fully certificated. And, quite apart from these problems, there was the problem of student transfer; if teachers developed sequences of instructions or materials which were unique to a given teacher or school, there would be no way to provide consistent instruction for transferring students. Finally, there is increasing evidence that basal readers are not only poorly conceived and written but also do not provide or promote effective instruction (e.g., Durkin, 1978-79; 1981).

Our goal was to develop an instructional delivery system that would address these problems. Providing materials that were centrally developed and successfully field tested would 1) reduce greatly if not altogether the time needed to prepare and organize materials, 2) require little inservice time, 3) be economical for schools in Chicago and elsewhere to implement, 4) standardize the definition, sequencing, and quality of the instruction necessary for mastery of each objective, 5) avoid some of the problems associated with exclusive reliance on basal reader instruction, 6) allow teachers to focus on teaching the students the contents of these and any materials they might choose to use with CMLR (see note 3), 7) reduce greatly the time needed for developing lesson plans, and 8) be easy for substitute teachers to use, thus maintaining the instructional program in spite of teacher absences and lack of inservicing.

Problems of Program Evaluation

Problems of collecting data and evaluating CMLR materials throughout the years of its development have been dealt with extensively elsewhere (Jones, 1981). However, for the purposes of this paper it is important to describe briefly one of these problems. During the 1979-80 school year, one Chicago school piloted a schoolwide implementation of mastery learning instruction with the CMLR materials. And, according to the intuitions and observations of the principal and his staff, the school had the kind of instructional year which produces successful achievement, including greatly increased time on task, enthusiastic teaching and learning, and high expectations for all students. Dozens of educators and reporters from around the country visited the school during the year and concurred:

> What is happening here--on the second floor of the all-black May Elementary School--is something rather extraordinary for American public education. . .this is an experiment--a struggle toward equalizing learning opportunities in the classroom.
> What's happening here is something called "mastery learning."
>
> (Robert Benjamin, The Cincinnati Post, February 11, 1980)

Johnny CAN read --they're certain of it."

This year . . .the school registered gains at all age levels that range from respectable to outstanding for an inner city school.

(Linda Wertsch, Chicago Sun-Times, July 6, 1980)

Furthermore, all agreed that the successful schooling was in no small way related to the use of CMLR materials and mastery learning techniques:

Only in Chicago are pre-tested materials handed to teachers along with training on how to use them; only here is mastery learning both a set of competency standards and a ready tool that teachers and students can use to meet these requirements.

(Benjamin)

The key to this year's progress at May . . . was Chicago's new mastery learning reading materials.

(Wertsch)

However, study of the implementation and formal program evaluation were not provided for in a budget reduction crisis which forced a moratorium on CMLR production itself. No systematic observations were taken with which to differentiate teachers and/or students who actively participated in the implementation from those whose classroom practices remained unchanged from previous years. The only data which are available are the results of the annual, citywide, standardized testing program. Within these test scores, it is not even possible to separate those who transferred into the school midyear. And these students typically have greater school problems and obtain lower test scores.

These are the kinds of data that are typically available to local school administrators, and it is generally difficult to use them as an accurate indication of either teacher or school effectiveness. Nonetheless, we reasoned that if we were correct in our hypothesis that the school's successful year was a result of effective mastery learning instruction, then the test scores of the school ought to change in the directions predicted by the theory.

Mastery learning theory predicts that as a result of more precise and more equitable instruction, a mastery learning group has 1) a higher mean achievement,

2) lower variation of achievement, and 3) lower relationship of prior ability to achievement than a group taught by traditional methods. A mastery learning research study usually compares mastery learning instruction to some other technique and uses these three indicators as evidence in support of the theory. The purpose of the next section is 1) to present a theoretical rationale for our methodology and then 2) to examine the "messy" school data which are available in order to search for building-level analogues to these classroom indicators. The appropriate phrase should be "to initiate the search," because any indices identified in this study must be subjected to theoretical and practical study. However, easily obtainable indicators of instructional effectiveness at the overall school level would be invaluable to researchers and school administrators alike.

Theoretical Basis

In 1963 John Carroll enunciated a "theory of school learning" which radically redefined the concept of aptitude. The theory was an attempt to explain the typical, normal distribution of school outcomes in terms of learning rates instead of innate learning limits. Prior to Carroll, normally distributed aptitude measures and their systematic relationship to outcome distributions were explained in terms of fixed distributions of innate abilities. There were "dumb kids" and "smart kids." Carroll suggested that is was more appropriate to think of aptitude as a measure of learning rate, or the time needed to learn. If there are fast students and slow students, and school provides a constant amount of time to all students, Carroll reasoned, then the fast students would learn a great deal while the slow kids learned very little. The result: a normal distribution of achievement highly correlated with prior aptitude or ability. Carroll further hypothesized that with additional learning time and with additional, alternative learning experiences, most children might be able to attain high levels of achievement.

Building upon his own work in the development of the taxonomy of educational objectives and upon his observations of the importance of instructional time in the IEA studies, Benjamin Bloom looked at the implications of Carroll's model from another perspective. Carroll had explained the differences in instructional outcomes in terms of variations in the degree to which students' learning needs were met. Bloom studied ways in which instruction could be reorganized so that students' needs would be met. This research was based on Carroll's conclusion that if such a reorganization could be accomplished, normal variation in outcomes would no longer obtain. In a sense, successful demonstrations of the theory of mastery learning will be the type of research which can support Carroll's theoretical model.

Bloom looked at instruction and learning not in abstract terms, but in terms of specific or concrete instructional objectives, materials, and practices. He suggested that each "course" of school study consisted of a set of instructional objectives organized into some logical sequence and grouped according to some unit of time and material. Under normal school circumstances, teachers provide a fairly homogeneous presentation or instruction to all students in a classroom, they provide a uniform amount of practice for all, and they allow a constant amount of learning time. Under these circumstances, some children accumulate learning errors or deficits in their mastery of course objectives. These errors compound over time, producing the familiar normal distribution of achievement. Furthermore, as the errors accumulate, the course becomes more difficult, and it is more difficult to persevere, the affective component of Carroll's model. These affective problems interact with the deficits in cognitive achievement to exacerbate the negative effects and to increase individual differences.

The alternative to traditional instruction is mastery learning (Bloom, 1976), a model of instruction based on the assumption that nearly all children

can learn when instruction is appropriate to needs. The model proposes to prevent the accumulation of learning errors by the systematic use of instructional feedback and correctives. In mastery learning instruction, the course is conceptualized in terms of a sequence and/or hierarchy of instructional objectives which are organized into learning units such as a chapter in a text. Within each unit, learning errors are diagnosed by a criterion-referenced, formative evaluation. Students who have failed to master specific objectives are identified, and an additional, alternative learning opportunity can be provided to remedy the deficit. As most students master most objectives, Bloom hypothesizes, the majority of students become quite similar with regard to learning achievement, learning rate, and enjoyment of learning. Thus the theory of mastery learning specifies a mechanic for 1) developing instructional materials, 2) increasing mean achievement by increasing individual achievement, 3) reducing variation in achievement by eliminating the end of the distribution which reduces the mean, and 4) reducing the relationship of prior achievement or aptitude to achievement by reducing variation in achievement.

These effects are observable in the distribution of achievement scores obtained by a group or classroom of children who have benefited from mastery learning instruction. But a school consists of numerous classrooms or instructional groups, each of which receives an idiosyncratic teaching/learning "treatment." This treatment is usually determined by the unique characteristics of the participants, the skill and knowledge of the teacher, the ability of the students, and the heterogeneity or disparity of abilities in the classroom. And many innovations which demonstrate effectiveness for the achievement characteristics of a sampling of classrooms simply do not affect school characteristics.

In order to increase the mean achievement of a school while simultaneously reducing the variation in achievement, it is necessary to improve the performance

of the majority of the classrooms in the building. Merely improving the achievement of a handful of rooms with the best teachers may increase the mean, but it will also increase the variance. Therefore, in addition to the theoretical criteria or hypotheses provided by mastery learning, we have also established criteria for successful building implementation of the CMLR and mastery learning instruction. These criteria are analogous to and based on those used in the criterion-referenced field test method for materials development. Recall that we determined that in order to provide effective remedial instruction for those who needed it, 50-60 percent of the students would have to demonstrate mastery by the time of the formative test. Similarly, we estimated that the same proportion of a faculty would have to be able to implement the CMLR with minimal administrative involvement if the principal were to be free to monitor and assist the remaining teachers.

As it turned out, the principal at May School at the end of the 1979-80 school year had identified twelve of thirty-two teachers (37%) for "intensive care." We assume, as in mastery learning instruction, that he will successfully remediate the majority of those twelve teachers. But until he does, we would not expect to see overwhelming mastery learning effects in the school data. Still, if 60% of the students in a classroom attained high achievement under mastery learning conditions, the data would show changes in the directions predicted by the theory. So we hypothesized that similar types of changes would be evident in the characteristics of the school data. Thus, our goal was not to attempt to estimate effects or effect sizes; rather, the goal was to discern effects by the type and pattern of change.

Data Source

In Chicago, the reading comprehension and the mathematics problem solving subtests of the Iowa Tests of Basic Skills (ITBS) are administered annually to

all elementary school students. These tests consist of eight overlapping levels of tests, each normed on a different age group. The different levels of the test are linked by the overlapping items, and the norms have been used to define a common grade level (GE) scale (e.g., a GE of 2.9 indicates a performance at the level of a child in the ninth month of second grade). In Chicago, children are assigned to a "functional" test level, rather than the age-related test level.

The bulk of the data to be discussed are from the results of the 1979 and 1980 administrations of the ITBS. Discussions of classroom characteristics and classroom gains are based on students for whom both 1979 and 1980 test scores were included in the building summary sheets. These usually consisted of two-thirds of the pupils in each classroom (n=20). Students who transferred in or out of the school during the period of time in question are not included since they are missing at least one of the scores. No attempt has been made to estimate within-class variance or changes of variance because of the missing data.

Another more general description of school achievement is the summary of age cycle scores in each building. These summaries reflect the scores of all the children in that age cycle in the building at the time of testing, independent of the amount of instruction that they received at the school. Gains are defined in terms of the differences between median 1979 and 1980 scores of the relevant age cycles. For example, the median gain of nine year olds is the median age cycle nine score from 1980, minus the 1979 median score for age cycle 8. A building variance statistic has also been derived, based on the distribution of the six age cycle gain scores (seven year olds have no previous year score, and last year's thirteen year olds have graduated).

Results

There are numerous ways to organize and summarize the achievement scores of a school; each retains some of the available information but also loses or

obscures a great deal of the information at the same time. Like different types of map projections, different ways of viewing school data have advantages and disadvantages. The trick in selecting the appropriate map or data projection is knowing the purpose to which it will be put. In this case, we selected two distinct ways of viewing the school data: 1) in terms of the distribution of classroom gains to meet the needs of a principal interested in monitoring his school's performance, and 2) in terms of the different age cycles, or grades, to meet the needs of a district superintendent interested in identifying the schools in his or her district which require additional instructional support.

From a principal's perspective, the school is not a population of students but a collection of classrooms. To affect a student's learning the principal has to affect the teacher and the classroom. To know how his building is doing, the principal has to know how the rooms are doing: which rooms have discipline problems, and which rooms are mastering their objectives. Therefore, we reasoned that the distribution of classroom gains could contain valuable information to help the principal understand his building. In addition, it seemed reasonable to expect that this distribution of classroom gains would behave like a distribution of gains within a classroom, demonstrating the theoretically defined effects of mastery learning instruction.

As can be seen in the tables on the following page, the distribution of classroom gains in 1980 under mastery learning instruction is different from the distribution of the previous year in precisely the ways predicted by mastery learning theory.

Distribution of Classroom Mean Achievement
Under Mastery Learning and Traditional Instruction

	1979	1980 Mastery Learning)
2.2		x
2.0	x	
1.8		x
1.6	xx	
1.4	x	xxxx
1.2	xx	xxxxxx
1.0	xxxxx	xxx
.8	xxxxxxxxxxx	xxxxxxxx
.6	x	xxxx
.4		xxxx
.2	xxx	
0.0	xx	
-.2	xx	x

Characteristics of the Distribution of
Classroom Scores Under
Mastery Learning and Traditional Instruction

		1979	1980
1.	Number of Classrooms	30	32
2.	Mean Classroom Pre-Score (Previous Year's Post Score)	3.55	3.53
3.	Mean Classroom Post-Score	4.29	4.43
4.	Mean Classroom Gain	.74	.90
5.	Standard Deviation of Classroom Gains	.53	.46
6.	Correlation of Classroom Pre-Score to Classroom Gain	.34 ($p<.05$)	.03

Though the pre-scores are virtually identical in both years, the gain in 1980 increased from 7.4 months to 9.0 months while the standard deviation of gains decreased. This difference is not statistically significant, at least with

these few degrees of freedom. But as we observe school data, almost any increase in means which is accompanied by a decrease in variance is rare enough to be significant. What is statistically significant in the data is the decrease of the correlation between classroom pre-test and classroom gain: from a statistically significant r=.34 to a nonexistent r=.03. We interpret these data as a clear indication of the effects of mastery learning instruction. The same teachers and virtually the same students achieved more in more classrooms independent of classroom prior ability, i.e., across age groups and related ability levels.

In addition to the characteristics of the distribution, we were intrigued by the classrooms at either end of the distribution. The principal of the school insisted that those classrooms with the highest gains had teachers who implemented CMLR instruction effectively while those classrooms which made a poor showing had teachers who had resisted the principal's instructional program. Unfortunately, he had not made his prediction before the test results were in. These might easily have been the most and least able teachers in the building. Or, following the logic of evaluators like Wiley (1978), the discrepancies between the results of the two sets of classrooms might reflect a critical difference in curricular emphasis of time allotment to reading. And we had no observations or controls to help us understand the differential effects of the two groups.

When we posed this dilemma to Dr. Bloom, he suggested a clever comparison that could help us in understanding this dilemma. While both the successful and the unsuccessful teachers had had CMLR materials available to them, no teacher used mastery learning materials or techniques to teach mathematics. Therefore, we decided to compare the math achievement to the reading achievement in a sample of each of the top and bottom classrooms. Because mathematics scores are not as important to schools as reading scores, we had to construct these

classroom gains by hand, which was a revealing experience. In most cases we were able to account for only 60-80% of the students in a classroom, which means that the remaining children were new to the school that year. Nonetheless, the comparisons of math and reading gains reveal the effect we had hypothesized.

As can be seen in the table below, looking only at reading scores, the principal was correct that he had identified the significantly less succcessful teachers.

Teachers vs. Teaching: A Comparison of
Reading and Mathematics Achievement
in the Classrooms of the Most and Least Successful
Reading Teachers at May Elementary School

	Reading Comprehension Mean Achievement	Mathematics Problem Solving Mean Achievement
Successful Mastery Learning Reading Instruction	$\bar{x}$ = 13.9 months n = 7 classrooms	$\bar{x}$ = 8.4 months
Unsuccessful Reading Instruction	$\bar{x}$ = 3.6 months n = 7 classrooms	$\bar{x}$ = 7.3 months

But looking at math scores, the teachers were approximately equally successful. Furthermore, the math scores show that the successful teachers did not achieve that success by ignoring mathematics instruction. It seems from the data that successful CMLR teachers were not only more successful than their peers in teaching reading, but they were far more successful than themselves when they did not use mastery learning techniques. As a check on this interpretation of the results, we repeated this procedure with the data from a similar, nearby school. In doing this we observed two classrooms which clearly revealed differences in curriculum emphasis: one with over a year's math gain and only one month of reading gain, and another with almost 1-1/2 years of reading gain coupled with only three months of math gain. No teacher at May school obtained

these results, so these classrooms were eliminated. The results of the remaining top and bottom classrooms at this traditional, inner city school are shown below.

A Comparison of Mathematics and Reading Achievement in the Classrooms of the Most and Least Successful Reading Teachers at a Traditional School

	Reading Comprehension Mean Achievement	Mathematics Problem Solving Mean Achievement
Successful Reading Instruction	x = 11.4 months n = 7 classrooms	x = 10.4 months
Unsuccessful Reading Instruction	x = 3.8 months n = 7 classrooms	x = 6.4 months

In this case, it is clear that the good teachers are consistently good in both subjects while the less able teachers are less successful in both reading and math. Thus we conclude that high gains obtained in the top classrooms at May do reflect the effects of mastery learning instruction. Additionally, we can see that principals who look only at narrow indicators of class progress may be getting a poor view of their staff.

From the perspective of a district superintendent or a member of the board of education, the school is no longer an organization of classrooms but a single, conceptual whole. From this perspective, it is desirable to have some simple, easily available indicators of school effectiveness. In Chicago, because we have ungraded schools, we report median scores for each of the age cycles included in the testing program (ages 7-13). With these scores it is possible to calculate the progress made by each age group (e.g., if 8-year-olds scored at GE=3.4 in 1979, and 9-year-olds made a year's gain in 1980). However, these scores fluctuate considerably and are difficult to interpret. Even the worst schools have some age cycles which make gains of better than a year's progress.

And throughout the city, children at the older age cycles make higher gains than those at the lower cycles, an artifact of functional-level testing. These anomalies of the data have previously made it very difficult to use these building summaries in any meaningful way.

In this case, the instability of the background information made it difficult for us to see a significant change in school achievement, though the gains in almost all age groups were the highest in the last four years. Despite this problem, we were convinced that this data showed the influence of effective, building-wide mastery learning instruction. So we decided to use the six age cycle median gains (7 year olds have no prior score) to represent the school. We calculated the mean and standard deviation of these six points:

Mean and Standard Deviation of Age Cycle Medians

Mastery Learning School

	$\bar{x}$	σ	
1977	.8 years	.56	No Mastery Learning
1978	.57	.58	No Mastery Learning
1979	.73	.44	8th grade ML
1980	1.03	.29	Building Wide ML

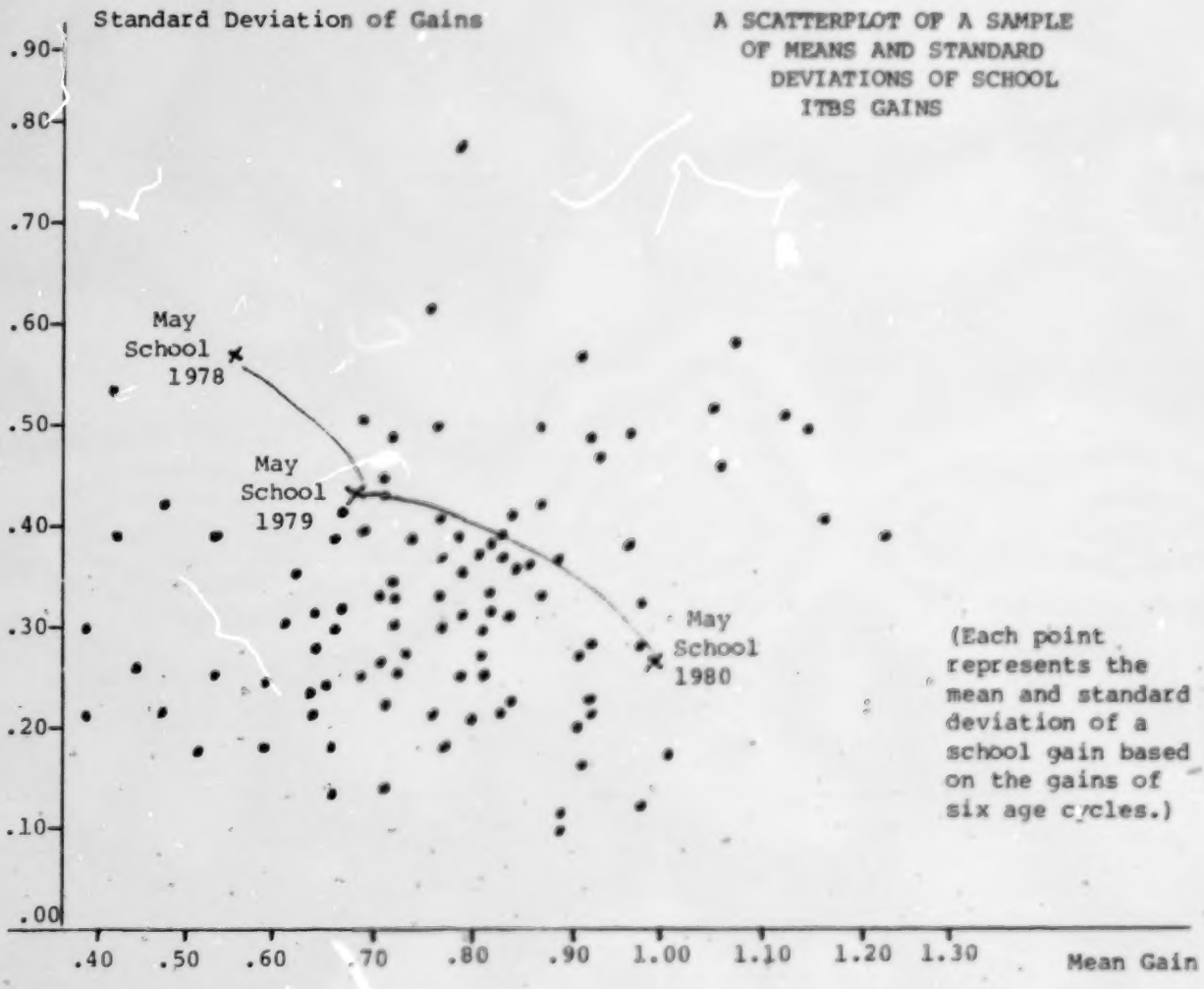
Mean and Standard Deviation of Age Cycle Medians

Three Similar and Nearby Schools

	School A		School B		School C	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
1977	.76	.26	.46	.44	.37	.21
1978	.63	.51	.81	.41	.87	.22
1979	1.13	.30	.72	.26	.88	.30
1980	.88	.30	.58	.15	.65	.19

Here we could see a clear trend over the last two years of increasing mean achievement and declining variance. It looked as though these summary statistics could be themselves summarized to reveal mastery learning effects.

In fact, it seemed as though low variance itself might be the critical indicator. So we arbitrarily selected about 50 (or 10% of the schools), calculated the age cycle means and standard deviations, and then made a scatterplot to portray the information:



We discovered that it is easy for a school to achieve a low variance of these medians: it is only necessary to obtain low gains. But as the gains tend to rise, so does the variance. Against this background, what made the improvement at May significantly different from gains typically achieved is precisely the effect predicted by mastery learning theory. Intuitively, this makes sense.

If there are a few good teachers at a particular grade/age cycle, or if a special program is purchased for fifth graders, or if a promotion policy is announced that affects seventh and eighth graders, we would expect the building scores to increase along with the variance. But if a principal is effectively managing the instructional program of the whole school, then we would expect this index to move in the direction that the May school index has moved.

It is not possible to determine that there is an optimal position in the plot, but based on the changes in one school over the last two years it is possible to identify a preferable direction of change. We speculate that this index could be useful in identifying improving and declining schools--an invaluable tool in school administration. The former, like May school, would have an index showing a rising mean and a declining standard deviation, while a declining school would be marked not only by falling scores but by a rising standard deviation of gains. We cannot help but wonder about the outlier school at the top of the scatterplot. While we cannot prove what we think to be true about this index, we do wonder what happened at that school this year.

We hope that this particular index and others like it are subjected to both theoretical and practical study. The former could include computer studies to determine the statistical properties of practical estimators of school mean gains and standard deviations. An interesting practical study would be to use this index as a design variable in a study of school effectiveness (Weber, 1971; Brookover & Lezotte, 1978; Edmunds, 1979). Declining and improving schools could be identified for naturalistic studies seeking differences in terms of previously identified effectiveness characteristics.

Discussion

We started this exercise with a dilemma familiar to program developers and school evaluators. We had introduced an educational innovation into a school

and participated in its implementation. We had observed dramatic changes in the building as a result: changes in teaching and learning, changes in attitude and school climate, changes in behavior, and changes in spirit. Subsequently, we had data from the school; not carefully designed and rigorously collected data, but the gross scores of students in the building on test day--the kind of data school officials usually have. And on the surface, this data looked good but not dramatic.

Our response to this dilemma has been to use our a priori knowledge about the changes which occurred in the operation of the school to look more closely at the data. The tools for this closer inspection are not the customary experimental design and statistical inference tools used to highlight effects by reducing error variance. Instead, we have used the theory of mastery learning to infer specific changes and patterns of changes which ought to occur in the data as a result of the specific changes in the school. In doing so, we have been able to identify such patterns of change even in data as messy as this. We believe that these types of data can be an extremely valuable addition to the basic research on mastery learning if further inquiry supports these initial findings. Furthermore, we believe that this approach of using theory to define significant results can be a valuable tool to program developers and evaluators, freeing them from the artificial constraints of research design. And we believe that the practical identification of useful statistics and indicators can open new dimensions for statistical study.

Our conclusion, if it can be called that, is that there is no such thing as "bad" data. There is a great deal more information in most data than we know how to release. What we need is not better data, but better ways to understand data.

Notes

1. From our requests for inservices and additional materials, we know that CMLR is being used in some classrooms in at least 230 schools. We also know that CMLR is being used schoolwide in about 10 schools. We have no count of the number of schools in which CMLR is being used in other cities.
2. The work of both of these researchers is in progress. Information about their studies was obtained by personal communications with them. For further information, contact Marshall Arlin at the University of Oregon and Lauren Resnick at the University of Pittsburgh.
3. It is recommended that the teachers use CMLR in conjunction with parts of any approved basal system, namely the developmental stories, the vocabulary components, and any of the writing assignments.

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